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# Biosynthesis of ZnO Nanoparticles using *Phyllanthus Emblica* Seed Powder and its Structural and Optical Characterization Studies

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## Abstract

*Presently the progress of green chemistry in the synthesis of nanoparticles (NPS) with the use of plants has engrossed a great attention. This study reports the exploit of aqueous extract of Phyllanthus emblica seed powder as an eco-friendly agent for the pattern of Zinc Oxide nanoparticle. The present exploration describes the synthesis and characterization of ZnO nanoparticles prepared by green technique using X-ray diffraction studies (XRD), Tunnelling electron microscopy studies (TEM), Energy dispersive analysis of X-ray (EDAX), Fourier transform infra-red spectroscopy (FTIR) and Photoluminescence studies (PL).*

**Keywords:** *Green technique; Phyllanthus emblica; TEM; XRD; Zinc oxide.*

## 1. INTRODUCTION

ZnO is a direct band gap (3.36 eV at room temperature) n-type semiconductor with large exciton binding energy of 60 meV, which have the promising applications in optoelectronics and photonics (Muthukumaran *et al*. 2012). It has attracted intensive research effort due to its unique properties and vast applications in pigments (Johnson *et al.* 2003), gas sensors (Comini *et al.*1869; Kang and Kim, 1993), rubber additives (Versloot *et al.*1992), solar cells (Aranovitch *et al.* 1979), varistors (Clarke, 1999), UV lasers (Tang *et al.* 1998) and other optical and opto-electonic devices (Arnold *et al.* 2003). Different physical or chemical synthetic methods have been used to prepare the ZnO nanoparticles such as thermal decomposition method, thermolysis method (Niasari *et al.* 2011), sol-gel method, chemical vapour deposition method (Yang *et al.* 2011), vapour phase oxidation (Hu *et al.* 2002), spray pyrolysis, precipitation method (Yang *et al.* 2004), Thermal vapour transport, condensation (Lao *et al.* 2003), co-precipitation method (Chauhan *et al.* 2010), and hydrothermal method (Savu *et al.* 2009). These chemical methods are very cost and leads to the presence of some toxic chemicals adsorbed on the surface that may have adverse effects (Pranjal Chandra *et al*. 2013).

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Increasing awareness towards green chemistry and biological processes has led to the development of an eco-friendly approach for the synthesis of nanoparticles. The use of environmentally benign plant leaf extract for the synthesis of zinc oxide nanoparticle offers copious profit of eco-friendliness where toxic chemicals are not used (Warren 2001; Vijayaraghavan and Nalini 2010). Based on the environmental friendly method, the present study we have prepared ZnO nanoparticles by using Phyllanthus emblica aqueous seed powder used as a reducing agent. The synthesised ZnO nanoparticles are characterized by X-ray diffraction studies (XRD), Tunnelling electron microscopy studies (TEM), Energy dispersive analysis of X-ray (EDAX), Fourier transform infra-red spectroscopy (FTIR) and Photoluminescence studies (PL).

## 2. EXPERIMENTAL METHODS

### 2.1 Synthesis of ZnO NPs by using *Phyllanthus emblica* seed powder extract

15 g of finely powdered seeds of *Phyllanthus emblica* were weighed. Then, 150 ml of double distilled water was added and boiled at 60 °C for 15 min. The obtained extract was filtered using Whatman No. 1 filter paper and the filtrate was

collected in 250 ml Erlenmeyer flask. Thereafter, 0.1 M zinc nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$) solution was added into 150 ml of powder extract of seeds and it was stirred constantly at 80 $^oC$ for 6 h. A yellow colour precipitate was obtained. Further the precipitate was dried at 120 $^oC$ for 6 h. The obtained ZnO NPs was annealed at 600 $^oC$ for 7 h.

## 3. RESULTS & DISCUSSION

### 3.1. Structural analysis

Phase and structural analysis of ZnO NPs prepared using Phyllanthus emblica is carried out by XRD analysis and shown in Fig.1. All marked diffraction peak positions in Fig.1 are in good agreement with the standard JCPDS Card (Joint Committee on Powder Diffraction Standards Card no. 36-1451). The corresponding X-ray diffraction peaks at (100), (002), (101), (102), (100), (103), (112) and (201) planes confirm the formation of hexagonal wurtzite structure of ZnO. The observed line broadening of diffraction peaks is an indication that the synthesized ZnO NPs are in the nanometer range. The full width at half maxima (FWHM) of major peaks increases and confirms the grain size reduction. The average crystallite size of ZnO NPs is calculated from the X-ray line broadening using Scherrer formula

$$D = \frac{k\lambda}{\beta D \cos\theta} \qquad (1)$$

where D is the size in nanometers, X is the wavelength of the radiation (1.5406 Å for Cu kα), k is a constant (0.94). βD is the peak width at half-maximum intensity and θ is the peak position. The average crystallite size of the synthesized ZnO NPS is 31 nm.

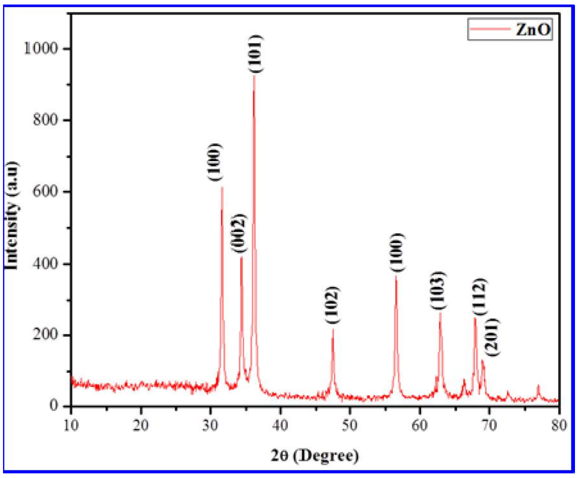


**Fig. 1: XRD pattern of green synthesised ZnO nanoparticles**

### 3.2 TEM Studies

The particle size and structural morphology of the synthesized ZnO NPs were investigated using TEM. The TEM images of the synthesized ZnO NPs are demonstrated in Fig.2, which explicate that the most of the base ZnO NPs are quasi-spherical and their diameter is about 30 nm. Due to the large specific surface area and high surface energy, same nanoparticles aggregate. The aggregation occurred probably during the process of drying.

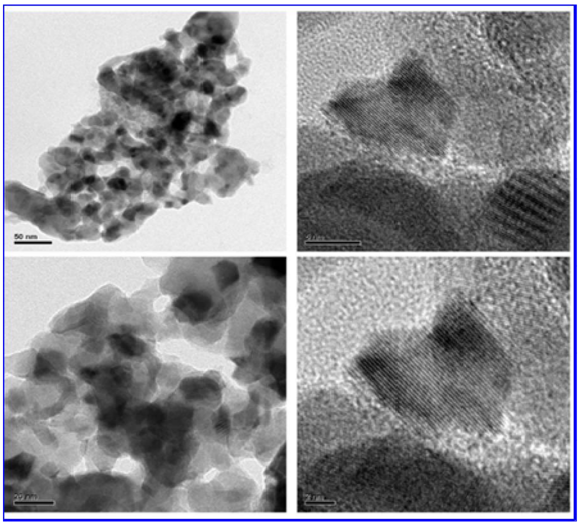

**Fig. 2: TEM images of green synthesised ZnO nanoparticles**

### 3.2 Energy dispersive analysis X-ray (EDAX) spectra

EDAX is used to analyze the amount of Zn and O elements are present in the sample. The typical EDAX spectra of synthesized ZnO NPs are shown in Fig. 3. It clearly shows that the elemental composition of Zn – 82.58 % and O – 17.42 % were observed in the sample. It reveals that there are no more impurities present in the synthesized sample.

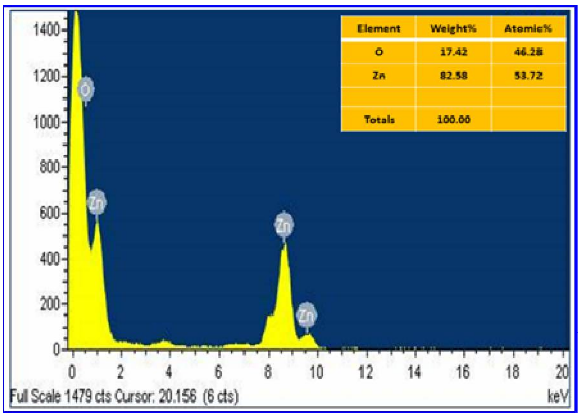


**Fig. 3: EDAX analysis of green synthesised ZnO nanoparticles**

### 3.3 FTIR studies

Fig. 4 shows that FTIR spectrum of synthesized ZnO nanoparticles. FTIR spectra exhibit strong vibrations at around 682 and 432 $cm^{-1}$ which are assigned to Zn-O stretching vibration frequencies (Mohammed Arshad *et al.* 2011). A broad signal at 3450 $cm^{-1}$ originates from hydroxyl group may be attributed from green extract. The peak observed at 2927 $cm^{-1}$ corresponds to the stretching vibrations of alkane group. C=O stretching frequency possibly appeared at 1635 $cm^{-1}$ (Anirudhan and Senan, 2011; Li *et al.* 2010) and the $-CH_3$ group was appeared at 1043 $cm^{-1}$.

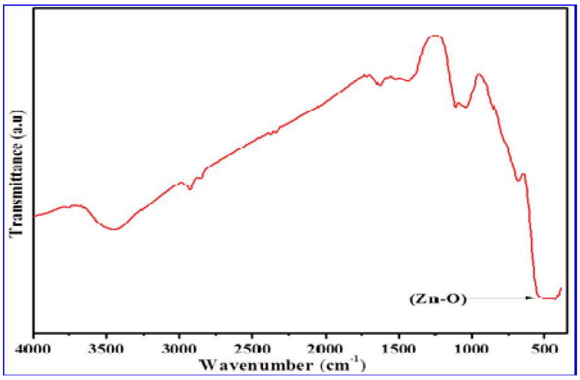


**Fig. 4: FTIR analysis of green synthesised ZnO nanoparticles**

### 3.5 Photoluminescence property

The optical property of as prepared ZnO NPs is studied by PL spectroscopy. A sharp and strong UV emission band is recorded at 388 nm. However, no defects mediated visible emission is recorded as shown in Fig.5. The UV emission is slightly red shifted as compared to bulk ZnO. Generally, the UV emission band originates from the direct recombination of the free excitations through an exciton-excitor collision process, while the visible emission is due to the impurities and structure defects in ZnO crystals (Rai *et al.* 2012).

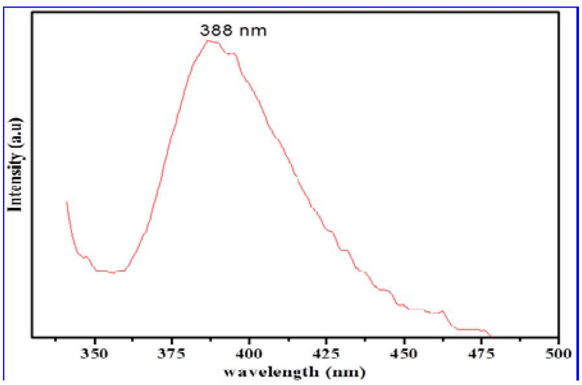


**Fig. 5: Room temperature PL spectrum of green synthesised ZnO nanoparticles**

## 4. CONCLUSION

The *Phyllanthus emblica* seed powder aqueous extractis an accountable for the synthesis of Zinc oxide nanoparticles. XRD study reveals that the average size was 31 nm in this green synthesis method. EDAX studies confirmed the purity of the synthesised ZnO nanoparticles. FTIR spectra confirmed that the Zn-O stretching vibration frequencies around 682 and 432 $cm^{-1}$. The PL studies confirmed that red shifted value observed at 388 nm due to defect crystal structure in ZnO NPs. Though chemical and green methods are trendier for nanoparticles synthesis, the biogenic green fabrication is a better choice due to eco-friendliness.

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